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FLIGHT EXPERIENCE WITH MANUALLY CONTROLLED UNCONVENTIONAL AIRCRAFT MOTIONS

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ABSTRACT

During 1976 and 1977, a modified YF-16 aircraft was used to flight demonstrate decoupled control modes under the USAF Fighter Control Configured Vehicle (CCV) Program. Higher levels of direct force control were achieved by the aircraft than had previously been flight tested. The direct force capabilities were used to implement seven manually controlled unconventional modes on the aircraft, allowing flat turns, decoupled normal acceleration control, independent longitudinal and lateral translations, uncoupled elevation and azimuth aiming, and blended direct lift. A miniature two-axis force controller was installed on top of the YF-16 sidestick controller for commanding the decoupled modes. At the pilot's discretion, the directional modes could also be commanded using rudder pedals.

The unconventional control modes were flight evaluated during simulated operational tasks, such as air-to-ground bombing and strafing, and air-to-air tracking and defensive maneuvering. The flight testing identified many actual and potential uses for these control modes, but also identified areas where refinements are needed to arrive at operationally suitable implementations. This paper describes the design, development, and flight testing of these new control modes. It includes lessons learned in the areas of unconventional control law implementation and controller design. The need for task-tailored mode authorities, gain-scheduling and selected closed-loop design is discussed.

INTRODUCTION

The Air Force Flight Dynamics Laboratory's Fighter CCV Advanced Development Program was conducted to develop and evaluate advanced control concepts for improving fighter aircraft mission effectiveness. Specific new control degrees of freedom were provided in an existing high-performance fighter. Control modes selected for implementation had been identified by previous research efforts as possessing the potential for significantly improving fighter aircraft performance. Use of these unconventional control modes provided the pilot with unique aircraft maneuvering capabilities. This program provided the first true test of

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the utility of these new capabilities. Design, modification and flight testing were conducted under contract to General Dynamics/Fort Worth.

The YF-16 shown in Figure 1 was uniquely suited as a testbed for the program. It served as a state-of-the-art baseline configuration with its full authority quad redundant analog Fly-by-Wire control system, sidestick controller, and advanced aerodynamic design employing vortex lift and leading edge maneuvering flaps. The aircraft was designed to be statically unstable longitudinally in subsonic flight with artificial stability being provided by the control system. Angle of attack and "g" limiting allowed full maneuvering without reliance on stall warning or cockpit instruments and provided maximum use of the airframe load factor capability throughout the flight envelope. This advanced control system design facilitated implementation of the new CCV control modes.

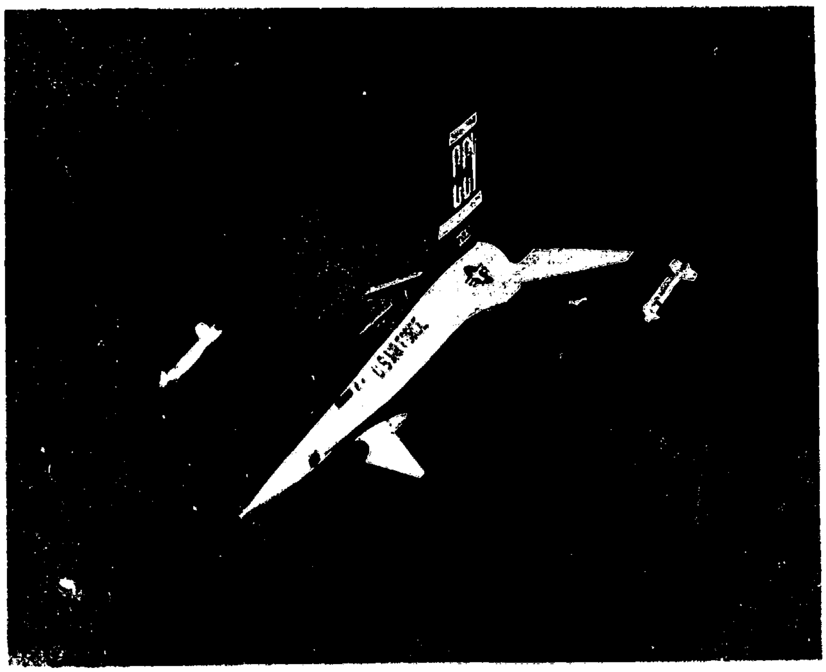

Fig 1 Fighter CCV Test Aircraft

DESIGN APPROACH

Cost effectiveness and safety considerations were major driving factors in the configuration selection and design. In this light only minor modifications were made to the YF-16 aircraft. Although providing a means of assessing the new control capability, this approach prevented overall control and aerodynamic design optimization. Exterior changes to the aircraft consisted of the addition of twin all-movable vertical canards. The new surfaces, canted outward 30 degrees from vertical, were attached at the engine inlet. The installation was accomplished without altering the external or internal mold lines of the inlet. Although separately actuated, the canards are deflected together by the same pilot-generated command signal. Use of the canards in conjunction with the rudder enabled direct sideforce to be developed by the aircraft. The flaperons were modified to allow both up and down symmetric deflections. Operation of the flaperons with the horizontal tail provided a direct lift capability.

An auxiliary analog computer was added to allow implementation of the new control laws. A fail-safe design was required. Additionally, the CCV modifications were not to result in degradation of the operational reliability of the basic YF-16 control system. That system was retained intact to provide suitable control and stability augmentation. The conventional YF-16 control system formed the baseline configuration for the program. It also served as the reversion configuration should problems cause CCV system disengagement. The addition of CCV signal interfaces was the only change to that system. Control reconfiguration was achieved by injection of bias signals and crossfeeds to alter the normal pilot commands or system feedbacks. Operation throughout the aircraft's envelope was needed for a valid evaluation of the unconventional modes. Gain scheduling was extensively employed to provide proper response as flight conditions varied. Emphasis was placed on obtaining maximum CCV mode capability across the mach-altitude range without creating adverse transients.

Crew station changes involved the addition of instruments such as sideslip, side acceleration, canard and flaperon position indicators to allow evaluation of CCV responses by the pilot. A CCV control panel was installed to enable mode selection, and modifications were made to the trim button on the sidestick controller to provide a means of commanding the open-loop CCV modes.

UNCONVENTIONAL CONTROL MODES

At the pilot's command were six open-loop modes illustrated in Figures 2 and 3. Direct control of the aircraft's flight path in two axes was provided by the A_n and A_y modes. The aircraft rotated in pitch and yaw with the velocity vector. In pitch, α was held constant while direct lift was generated on the aircraft. Sideslip remained zero during use of the sideforce mode as side acceleration was generated allowing turning of the aircraft without banking. Attitude control at constant flight path angle was available with the α_1 and β_1 modes resulting in independent fuselage pointing in either axis. Vertical and lateral translations were provided by the α_2 and β_2 modes. In this case vertical velocity and side velocity were the controlled parameters at constant aircraft attitude. Thus the aircraft could effectively elevate or side step.

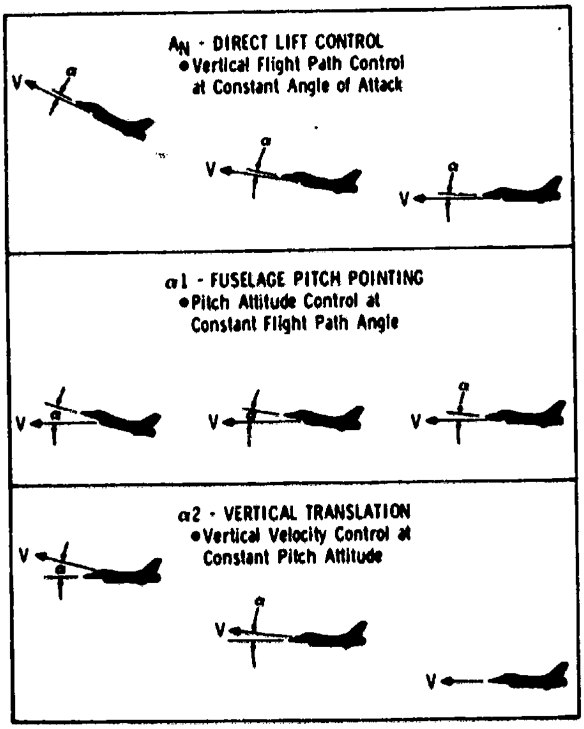

Fig 2 Open-Loop Longitudinal CCV Modes

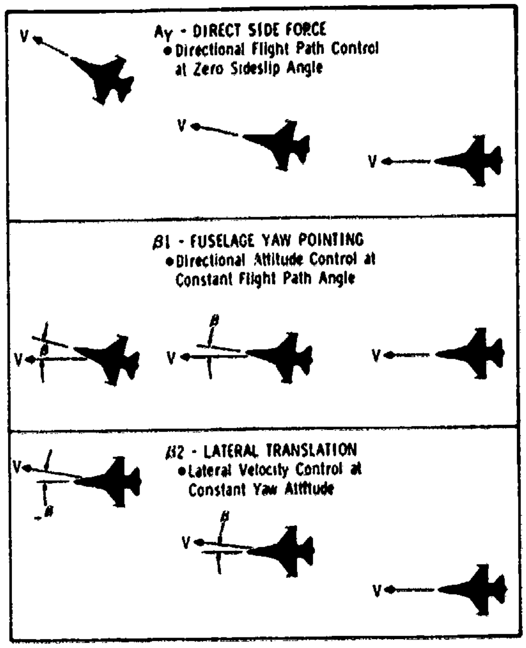

Fig 3 Open-Loop Directional CCV Modes

One closed-loop mode, Maneuver Enhancement (ME), was also available to the pilot. Direct lift was blended with basic aircraft pitch control in this mode. It provided an initial direct lift during a maneuver which was washed out as the commanded aircraft normal acceleration was obtained. Use of this capability resulted in maneuver quickening. Due to the use of normal acceleration feedback, a level of gust alleviation was also provided as illustrated in Figure 4.

Implementation in accordance with the approach of an "add on" design is illustrated with the simplified block diagrams in Figures 5, 6 and 7. The conventional YF-16 control system is shown in solid black in the figures. Dashed lines indicate the CCV modes. For the three open-loop longitudinal modes, the pilot commands flaperon deflection directly with the elevator being driven through a scheduled crossfeed gain. Biases to prevent opposition of the CCV commands are computed and introduced into the YF-16 control system. In the case of the A_n mode, Figure 5, stick command and pitch rate paths are modified by the bias signals. CCV system gains were determined using wind tunnel data and digitally predicted aircraft responses.

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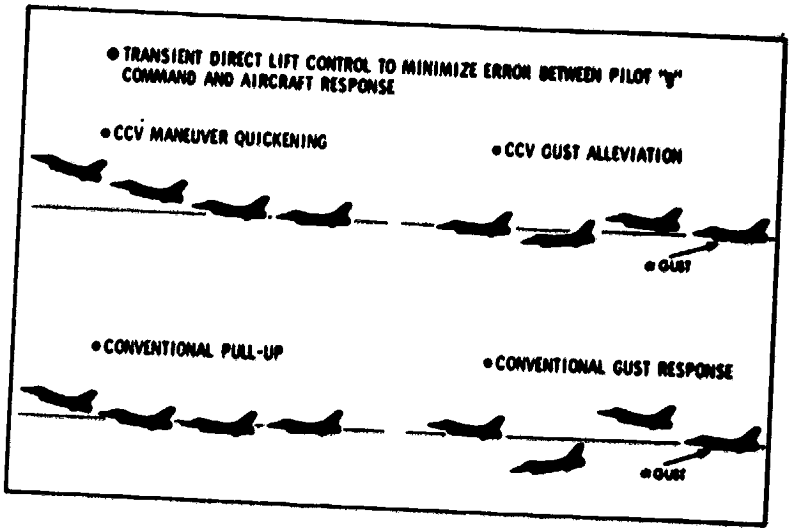

Fig 4 Maneuver Enhancement Mode

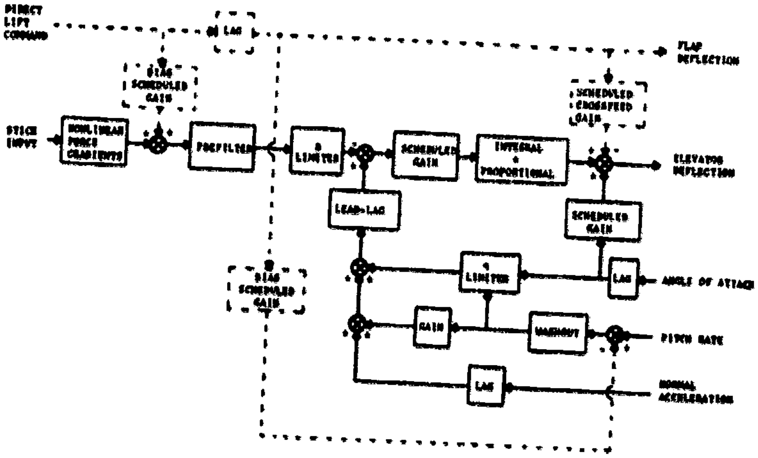

Fig 5 Simplified Functional Block Diagram of the A_n Mode

The directional modes are structured in much the same manner. The pilot commands a canard deflection with an appropriate crossfeed to the rudder as shown for the direct sideforce mode in Figure 6. In this case a gain scheduled crossfeed to the flaperons is needed to counter rolling moments from the canard-rudder deflections. Biases are also added to the yaw rate and lateral acceleration feedbacks of the basic control system.

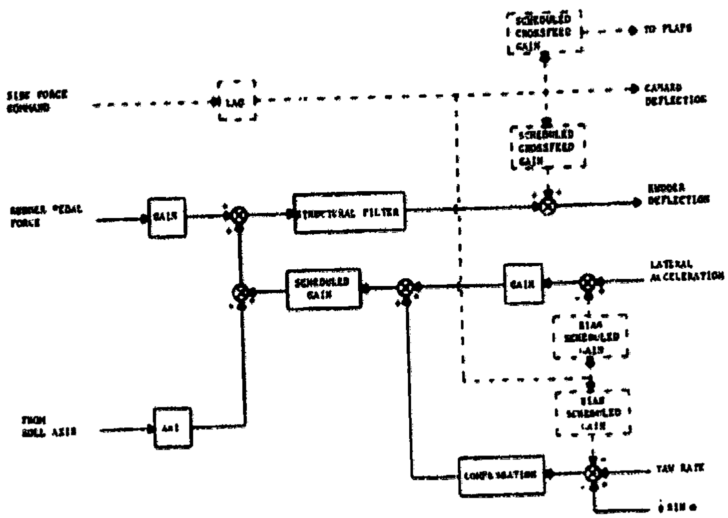

Fig 6 Simplified Function Block Diagram of the A_y Mode

The one exception to this type of implementation is Maneuver Enhancement. As shown in Figure 7, the error between pilot command and aircraft normal acceleration drives the flaperons and horizontal tail. A washout in the pitch rate feedback path, and integral plus proportional control in the forward path, provides a "g" command response in steady state. Thus as the aircraft attains the commanded "g" level, the direct lift flaperons return to zero deflection. The technique provides an instantaneous direct lift for maneuver quickening. Gust alleviation is obtained when the normal accelerometer feedback senses gust induced aircraft response and drives the flaperons to counter it.

Minor modifications to the YF-16 cockpit were made to allow use of the CCV modes. Specific modes are selected by the pilot using the CCV control panel shown in Figure 8. Any of the three open-loop longitudinal modes can be commanded by fore or aft force on the CCV controller installed on the YF-16 sidestick, Figure 9. The trim switch was replaced with the two-axis CCV force controller, and the normal "coolie hat" thumb button was retained. The three open-loop directional modes can be selected for operation through either rudder pedal inputs or left/right force on the CCV controller. Besides mode selection the control panel also provides the pilot with pitch and roll autopilot functions as well as mode purification capability. Purification was designed to allow engineering evaluation of the modes by enabling various feedbacks to force "pure" steady state uncoupled aircraft motion. In this way the adequacy of interconnect and bias gain schedules based on predicted CCV responses could be ascertained. The control panel also provides a means of removing side acceleration, A_y, feedback to the rudder in the basic control system. Various self-test functions were also included for system checkout and diagnosis on the ground.

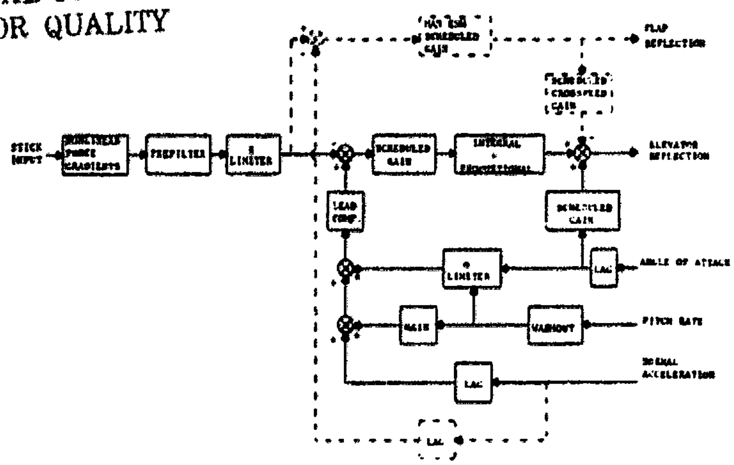

Fig 7 Simplified Functional Block Diagram of Maneuver Enhancement

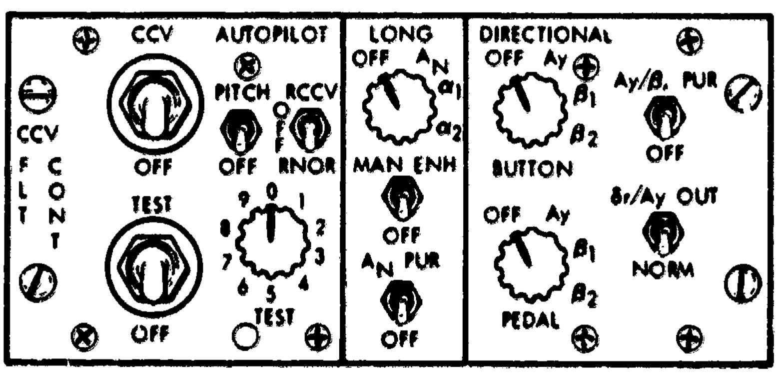

Fig 8 CCV Control Panel

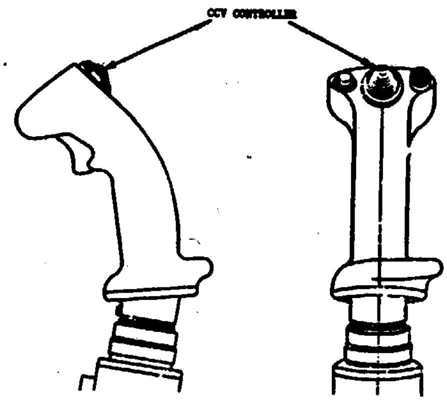

Fig 9 CCV Controller Installation on Sidestick

The basic airplane sidestick controller is essentially a force stick although the sensors employed are Linear Variable Differential Transformers which measure a very small displacement of the stick resulting from forces applied by the pilot. Maximum command in pitch requires 31 lbs.,and maximum roll requires a little more than 15 lbs. Both axes have parabolic stick force versus command gradients. The CCV button has a 0.1 lb. deadzone with a linear force versus command gradient up to a maximum of 3.1 lbs.

FLIGHT TESTING

The flight test program consisting of 87 flights and totalling over 125 flight hours was conducted at Edwards AFB in California. Figure 10 presents the range of flight conditions over which testing was performed. Initially the flight envelope was cleared in tests to identify flutter, aeroservoelastic instabilities, or stability and control problems. The effect of the canards addition on inlet/engine operation and the aerodynamic destabilizing effects were also evaluated during the initial tests. Preliminary checks were performed to verify proper functioning of the CCV control system. Engineering evaluations were then conducted to ascertain the functional adequacy of the CCV control system design and to obtain data for detailed evaluation of the various mode characteristics. Figure 10 also indicates test conditions for evaluating predicted performance improvements with Relaxed Static Stability (RSS). Although not covered in this paper, the aircraft's fuel system was modified to allow a wide range of center-of-gravity locations to be evaluated during the later portion of the test program. Finally quasi-operational tasks were conducted simulating air-to-air gunnery, formation, refueling, air-to-ground bombing and air-to-ground strafing.

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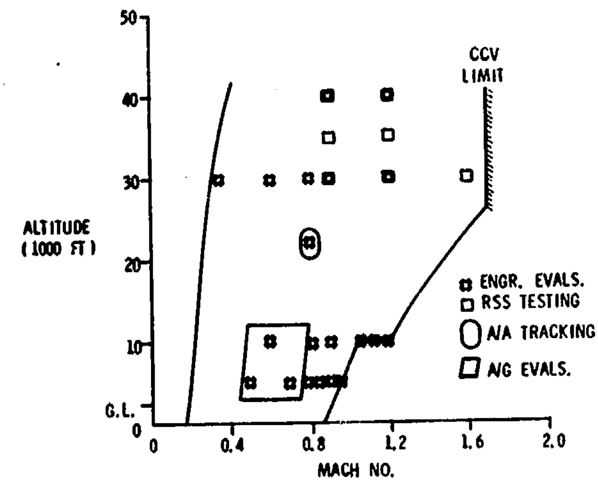

Fig 10 Primary Test Points

The CCV modes produced responses as predicted, and the modified aircraft was found to be free of instabilities. It also possessed adequate handling qualities throughout the flight envelope up to its angle of attack and sideslip limits. No adverse effects of the canards on inlet or propulsion system performance were detected. Although the canards were destabilizing both longitudinally and directionally, the YF-16 control system provided stability augmentation that effectively compensated for the change. The engineering evaluations provided data to allow refining of the CCV control system gain schedules which had been selected originally on the basis of wind tunnel information. The evaluations also verified the available CCV mode authorities. Direct lift levels of up to $\pm$ 1.5 g's and side force levels of 0.9 g were obtained. These capabilities varied considerably with flight conditions since the design was to obtain maximum capability, and not to provide uniform authority. Yaw pointing levels approaching $\pm$ 5 degrees and pitch pointing of approximately $\pm$ 2 degrees were realized. Translation authorities of 1500 fpm rate of climb for the α_2 mode and 40 kts side velocity for the β_2 mode were demonstrated.

The Handling Qualities During Tracking (HQDT) technique developed at the NASA Dryden Flight Research Center and the Air Force Flight Test Center was used for engineering analysis of the CCV modes during tracking. For this technique, scored gun camera film is used to obtain a quantitative measure of handling qualities, control system characteristics, and precision controllability during high-gain tracking tasks. A fixed depressed reticle is used in a preplanned tracking task employing in this case an F-4 or T-38 target aircraft. The air-to-air tracking maneuver consisted of windup turns (WUT) to 4.5 g's and 3g constant turns. The technique was also applied to air-to-ground runs with limited success. Unfortunately, the technique does not resemble most air-to-ground delivery techniques. RMS, mean, and median tracking errors along with time histories of pipper position relative to the target are provided by the technique. This data was used in connection with pilot ratings and comments to evaluate the CCV modes' usefulness. Ordnance was not actually delivered because the YF-16 testbed did not have a weapon delivery capability.

Early in the evaluations, results from tracking with Maneuver Enhancement indicated the usefulness of this mode. Figure 11 is a longitudinal parameters comparison of the aircraft with and without ME during a windup turn tracking task. The reduction in magnitude of pitch rate perturbations and pilot inputs indicates a useful mode for precise tracking. Tighter "g" control was available to the pilot, and small corrections could be made without causing large rotational rates. This preliminary assessment proved to be correct when pilots from the F-16 Joint Test Force evaluated the modes in simulated air-to-air gunnery.

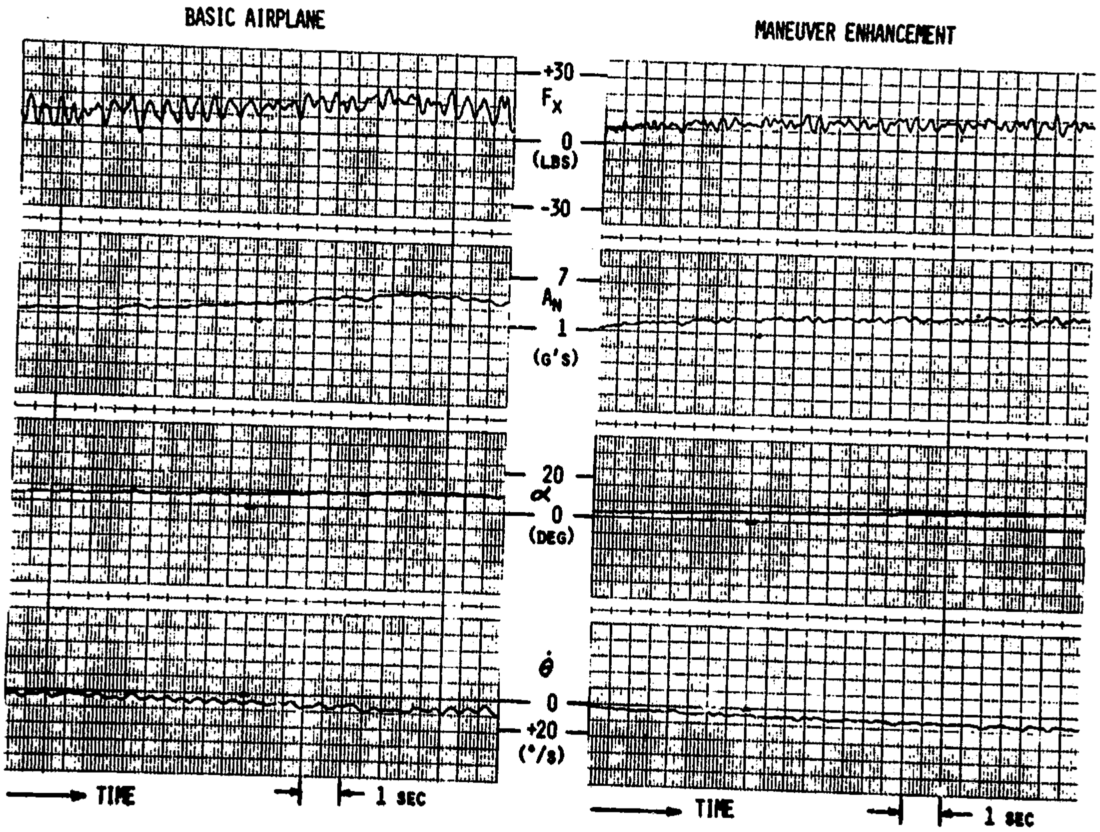

Fig 11 Windup Turn Tracking

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Overall assessment of the CCV modes for various operational tasks are shown in Figure 12. This is a consensus of pilot opinion on the potential improvement these modes could provide. A "G" or green rating indicates that the mode is either preferred or has the potential for improvement over conventional controls. The "Y" or yellow rating is used to denote that the mode did not show a potential improvement over conventional controls or that pilot ratings and comments were inconclusive.

	MANEUVER ENHANCEMENT/ GUST ALLEVIATION	DIRECT FORCE A_N	DIRECT FORCE A_Y	FUSELAGE POINTING α	FUSELAGE POINTING β	TRANSLATION α	TRANSLATION β
AIR-TO-AIR TASKS							
TRACKING	G	G	G	G	G	Y	Y
DEFENSIVE MANEUVERING	G	G	G	N/A	N/A	Y	Y
FORMATION/STATION KEEPING	G	Y	Y	N/A	N/A	Y	Y
AIR-TO-GROUND TASKS							
STRAFING	G	Y	G	G	G	Y	G
DIVE BOMBING	G	Y	G	N/A	Y	Y	G
APPROACH/LANDING	G	Y	Y	Y	Y	G	G

G GREEN-POTENTIAL IMPROVEMENT

Y YELLOW-INCONCLUSIVE/CONFLICTING ASSESSMENT

Fig 12 CCV Mode Assessment

Maneuver Enhancement was considered an improvement as it was implemented on the test aircraft in all air-to-air tasks. It provided tighter control in a tracking situation without the usual rotational perturbation. Pilot control was not complicated by an additional controller since this was a blended mode on the normal sidestick. Washout of flaperon deflections prevented saturation problems of the limited authority direct lift capability.

The direct force modes, A_n and A_y, were preferred over pointing or translation for precise tracking. The mechanization allowed pilots to "beep" CCV commands using the button controller in much the same manner as a trim switch. It provided an immediate precise change in flight path. Such a "beep" technique was realizable because command and release cause no objectionable pipper transients. The direct force modes were also considered to hold promise for some unusual and effective defensive maneuvering capabilities, but larger authority levels than obtainable on the CCV YF-16 were desired by most of the pilots.

The pointing modes were difficult for manual pilot control. Although providing reasonable authority and precise fuselage pointing, the command had to be held in continuously. Upon release of the CCV controller, the pipper moved sharply away from the target as the aircraft returned to align with the velocity vector. This proportional input on the CCV controller,while trying to keep the basic tracking solution through changing forces on the sidestick,resulted in what one pilot referred to as a hand conflict. A tendency existed to rapidly reach and hold full pointing capability as the maneuver changed. The pilot had to immediately realize when maximum capability had been reached and revert to basic aircraft control for further error reductions. This would result in maneuvering the aircraft with full pointing capability being commanded and at times introduced unwanted lags in tracking. Even with these drawbacks, the mode was rated highly as far as its potential for improvement. Most pilots commented that an automatic tie-in with the fire control system would make a very effective gunnery system.

The translation modes were implemented with slow onset rates and low steady state authorities which made them unsuitable for air-to-air combat maneuvering. Due to the open-loop design, the aircraft had a tendency to coast after a translation command had been removed. This was bothersome to the pilot as he tried to close on another aircraft since exact final position was not easily predicted. The translation modes could be used for formation/station keeping; however, the task was adequately handled with the basic aircraft controls. Thus, a clear need for improved means of accomplishing the task did not exist. The one exception was application in refueling operation. The CCV modes were believed to offer significant advantages in this case. Unfortunately, due to the limited redundancy in the mechanization and safety considerations, such applications could not be evaluated. Refueling with CCV modes engaged was prohibited.

For the air-to-ground work, Maneuver Enhancement again demonstrated an improvement as implemented on the test aircraft (Figure 12). This was primarily due to: 1) the gust alleviation capability it provided; and, 2) the increased response when pulling out of a dive. The manual control task was not significantly changed with the blended implementation on the sidestick. Normal piloting techniques could be used for task accomplishment.

Direct side force, A_y, received favorable pilot rating for both strafing and dive bombing. The primary advantage was elimination of having to roll-pull-roll back to make directional corrections. The effect of each correction could be immediately and easily determined since the basic sight picture remained unchanged. Rudder pedals for A_y commands were well liked,and the pilots easily adapted to their use. The authority provided appeared excessive for terminal tracking. The A_n mode found only sparing application in the air-to-ground tasks because longitudinal control posed no specific problem and was easily accomplished with the normal stick commands. Use of the force button was not natural for the pilot in these tasks, and cross-talk between button and stick existed.

Pointing capability in both axes was found useful for strafing runs. Two techniques were used with pitch pointing. In the first method the pipper was allowed to walk up to the target and was then held on the target with the pointing capability to provide a longer firing opportunity. The second technique involved using full nose down pointing throughout the run. This allowed considerably more ground clearance during low-level passes. For bombing, the pointing modes were not appropriate since the velocity vector was not being changed. There was one exception. It was possible to use the mode to mimic the translation mode's crosswind cancelling capability with higher responsiveness. This was accomplished by establishing a crab in the normal manner to counter the crosswind and allow the flight path to cross the target. Then yaw pointing was used to align the nose with the resultant velocity vector giving the pilot a good HUD sight-target picture.

Longitudinal translation was useful in the power approach for maintaining a desired glide path. However, due to the limited authority and slow response,it was not satisfactory for strafing or bombing. In addition, the normal longitudinal command provided adequate control for these tasks. The lateral translation capability was useful for crosswind corrections during both landing approach and dive bombing. It could also be used to attack moving targets from an approach perpendicular to the target's motion. Slowness of response and the requirement to hold a constant button force during mode usage were considered drawbacks of these two modes.

SIMULATION INVESTIGATION

Results of the flight testing showed the need for additional unconventional control mode studies. Pilot comments clearly indicated the capability provided by the unconventional modes had the potential for improving the aircraft's effectiveness, but some aspects of the particular implementation on the test vehicle were unsatisfactory. The two-axis force button selected after evaluation of several types of controllers in a fixed-base simulation at General Dynamics provided adequate for engineering evaluations but lacking for operational usage. Various mode authorities, responses and mechanizations were found to be inadequate for tracking and weapon delivery tasks. The flight test effort had been extremely ambitious in terms of flight rate. This restricted modifications from being accomplished to the CCV hardware except to satisfy safety-of-flight requirements. As a result of these findings, the Flight Control Division of the Flight Dynamics Laboratory initiated an extensive simulation investigation to be conducted on the Large Amplitude Multi-mode Aerospace Research Simulator (LAMARS) shown in Figure 13. LAMARS comprises part of the Flight Dynamics Laboratory's Engineering Flight Simulation Facility at Wright-Patterson. The sphere, containing a single place cockpit, and the 30 ft. support beam are computer controlled to provide realistic cockpit motion cues. The pilot's visual display is projected on the interior of the 20 ft. sphere. It can be either a simple sky/earth image or projection of terrain features from one of two 15 ft. by 48 ft. terrain boards. An air-to-air target aircraft projector is also included for combat simulations. The spherical contour provides a maximum 266 degree horizontal and 108 degree vertical field of view. Motion capability of the simulator is listed in Figure 14. A hybrid computing system forms the core of the simulation facility. Nonlinear aerodynamics and the complete YF-16 and auxiliary CCV control system have been modeled on the computers.

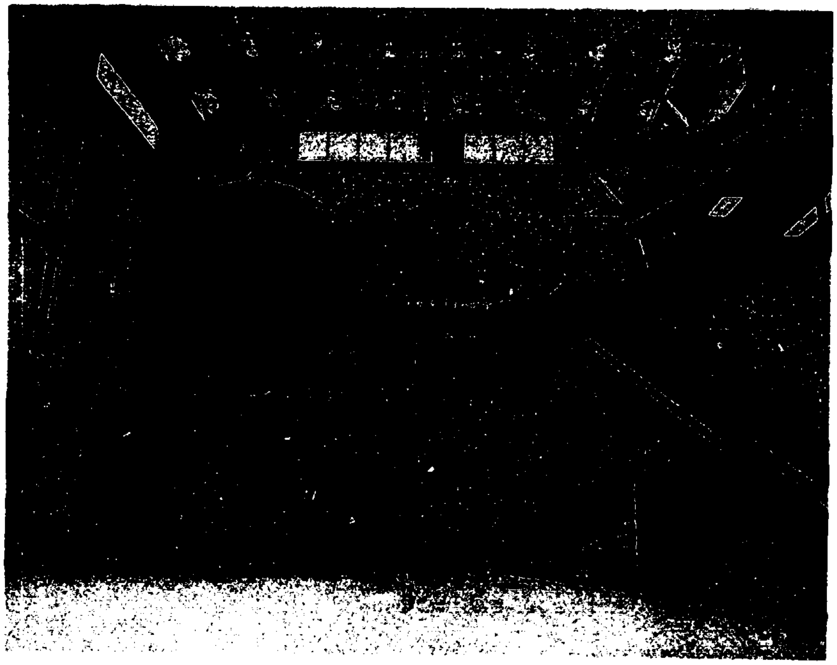

Fig 13 LAMARS Facility

Major emphasis of the simulation program will be the development of Task-Oriented CCV control modes. The LAMARS effort will pursue two different approaches in the investigation of unconventional aircraft maneuvering capabilities. The first will be concerned with minor modifications to the CCV modes as they were implemented on the YF-16. This approach is aimed at resolving basic problems/shortcomings highlighted during the flight test program. Candidate changes are listed below:

- CCV controller gradient variations
- Alternate gain scheduling
- Integral command of pointing and translation modes
- Elimination of operating restrictions

° Mode authority matching and tailoring

	DISPLACEMENT	NO-LOAD VELOCITY	STALL ACCELERATION
BEAM-VERTICAL	± 10 FT	13 FT/SEC	± 3 G
BEAM-LATERAL	± 10 FT	10 FT/SEC	± 1.65 G
SPHERE-PITCH	± 25 DEG	60 DEG/SEC	± 400 DEG/SEC^2
SPHERE-YAW	± 25 DEG	50 DEG/SEC	± 200 DEG/SEC^2
SPHERE-ROLL	± 25 DEG	60 DEG/SEC	± 460 DEG/SEC^2

Fig 14 LAMARS Motion Capability

The gradient variations and gain scheduling are both intended to reduce mode sensitivity evident in the air-to-ground tasks. An integral mechanization would allow "pulse" type inputs without requiring the pilot to hold CCV commands during a tracking task. Unfortunately, this quickly results in mode authority saturation. A trim type follow-up technique is needed in which adverse pipper motion does not result. In order to develop "pure" CCV modes and insure safety from failures with the limited redundancy employed in flight test, rather severe restrictions were placed on several modes. The emphasis will now be on obtaining "useful" modes by reducing these restrictions such as bank angle and α limits and accepting impure responses. In the interest of providing the pilot with a useful tool, authority of the modes will be tailored to the operational task and matched in both axes for control harmony. In addition, the CCV modes will be evaluated with several HUD gun-sight systems to ascertain the benefits and problems associated with such use.

The second approach involves alternate methods of providing the CCV capabilities to the pilot and new control law structures. It includes consideration of the following techniques:

° Blended modes using only the YF-16 sidestick

° Weapon-line stabilization and improved gust alleviation

° Closed-loop velocity command

Based on the acceptance by the pilot of the maneuver enhancement mechanization and the fact that pilot workload was actually increased with the addition of another controller in the cockpit, blending of CCV modes with the basic aircraft controls is needed. Such blending must not result in adverse transients on initial command or when reaching maximum CCV authority. In addition, a means must be provided to washout CCV inputs to prevent combat maneuvering with residual canard or flaperon deflections. The mode to be blended will be selected based on its usefulness in the particular mission phase being flown. The techniques being considered included frequency selective separation of CCV versus conventional stick inputs using filter techniques and separation based on detected command magnitude and rate. In both cases gradual removal of the CCV mode in steady state is required. A recentering technique allowing placement of CCV command gradient within the basic control system stick force gradient is also being examined. Such a technique would provide the CCV capability as a vernier control for the pilot while allowing normal aircraft maneuvering for large inputs. Such a recentering scheme must allow full aircraft capability to be commanded and must not produce an unacceptable stick force per "g" relationship.

Work is being conducted to arrive at an optimum design of maneuver enhancement to provide weapon-line stabilization for improved gunnery. In this application the primary design objective is faster acquisition and better tracking as opposed to simply quickened maneuvering response. Changes to improve the gust alleviation capability are also being studied, but the focus is on reducing pipper disturbance rather than improving ride quality.

Closed-loop design providing a velocity command system for the translation modes is aimed at faster mode response and the elimination of coasting. With such a design, the pilot would command vertical or side velocity instead of flaperon or canard deflection. The control system positions the surfaces as needed to develop or cancel independent translations. This would improve mode usefulness in tasks requiring precise positioning and possibly allow application to combat maneuvering.

The flight test also accented the need for more operationally oriented evaluation techniques. The HQDT constant "g" and WUT tracking maneuvers for 20 to 30 seconds are not reasonable for representation of the air-to-air combat situation. Although providing useful information on basic control characteristics in a tracking task, it is not well suited for task-oriented design. In an effort to solve this problem, the LAMARS simulation will be using various weapon delivery scoring techniques based on aircraft position, target location and munition ballistics. However, HQDT type data will be taken for correlative purposes. Target aircraft combat algorithms to allow realistic operational task evaluation of the CCV modes have also been developed.

CONCLUSIONS

Flight testing of the Fighter CCV has provided valuable insight into the implications to manual control of uncoupled aircraft motions. A pronounced learning curve was encountered due to the very unusual maneuvers possible with the CCV modes in the flight evaluation. While providing additional capability, the open-loop modes sometimes resulted in an increase in pilot workload with the addition of another controller. Use of rudder pedals for A_y command was natural for the pilot. The one blended closed-loop mode, Maneuver Enhancement, was found to be beneficial during all evaluation tasks. Although requiring optimization, the blending technique was readily accepted by the pilot. The flight test program demonstrated the feasibility of decoupled aircraft control and verified predicted performance levels. It also provided an indication of the usefulness of these new control modes in operational tasks.

The urgent need for task-oriented control mode investigations was clearly indicated during the test program. The CCV modes were implemented from an engineering standpoint of obtaining "pure" motion with well-behaved responses and maximum capability throughout the flight envelope. Emphasis must now be placed on designing to the specific task application. Through the use of AFFDL's large moving-base simulator and lessons learned from flight testing, engineering efforts are underway to provide CCV capabilities to the pilot in a manner that will significantly improve fighter aircraft effectiveness. Prior to adaptation in future designs, these capabilities must be provided in ways which do not complicate the manual control task. A multimode approach is indicated in which the pilot is provided with various predetermined combinations of conventional and CCV control tailored to the specific mission phase.